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Switched reluctance motor

In a switched reluctance motor with a large rotation speed range, low currents in the motor and in the inverter (25) are achieved in that each phase winding (17/18, 19/20, 21/22) has a tap (53, 55, 57) located approximately in its centre, which is connected on the one hand via a freewheeling semiconductor switch (65, 67, 69) to one pole (71) and on the other hand via an additional switching transistor (59, 61, 63) to the other pole (73) of the direct voltage source (23). This centre tap (53, 55, 57) does not become effective until after the rotor reaches a specific rotation speed. The reluctance motor is distinguished by low losses and by more cost-effective rating of the components.

The following particulars are derived from the documents submitted by the applicant.

Description

The invention relates to a switched reluctance motor, particularly as a drive motor in electrically driven motor vehicles, washing machines, lawn mowers and in similar machines to be driven electrically, of the type indicated in the preamble to claim 1.

Switched reluctance motors are already used for positioning drives in motor vehicles, especially in fans in motor vehicles, since these are also characterised by simple and robust construction and are also of moderate cost and maintenance-free. These switched reluctance motors usually have a plurality of poles both on the stator and the rotor, i.e. they are double limb pole machines. Here, an effect concentrated on each stator pole is provided, but there are no magnets or windings on the rotor. Each pair of diametrically opposite stator pole windings is connected in series or parallel, in order to form an independent machine phase winding of the multi-phase SR machine. Motor torque is formed by switching the current in each motor phase winding in a specific sequence which is synchronised with the angular position of the rotor, so that there is a magnetic attraction force between the rotor poles and the stator poles, which move closer to each other. The current is switched off in each motor phase before the rotor poles which are closest to the stator poles of this phase revolve past each other at the lined-up position. The torque generated depends on the direction of the current, so that current pulses in one direction, which are synchronised with the rotor motion, can be applied to the stator pole windings by an inverter in which elements such as transistors and thyristors switching the current in one direction are used.

Switched reluctance motors are used in electric drives with a large range of rotation speeds, speeds of 0 to 9000 rpm being required in motor vehicle drives and speeds of 0 to 15,000 rpm in washing machines. For these applications, fixed firing angles do not always give sufficient machine torque over the required large speed range. Moreover, high currents are present in the lower speed range, and these lead to high losses in the motor and in the converter and thus to poor levels of efficiency. The high currents also require corresponding power switches in the converter.

The invention addresses the problem of creating a switched reluctance motor which generates sufficient torque over a large speed range with good efficiency. This problem is solved by the features characterised in claim 1.

The reluctance motor according to the invention requires low currents both in the motor and also in the converter, so that smaller losses arise in the converter and it becomes possible to choose smaller, cheaper power semiconductors for the converters. This also increases efficiency.

Further advantageous embodiments of the subject of the invention are to be found in the further dependent claims. The invention is described below in more detail on the basis of examples of embodiment.

The figures show the following:

Figure 1 shows a simplified section through a switched reluctance motor, Figure 2, a circuit arrangement of an inverter and Figure 3, a block diagram of the control circuit arrangement for the SR motor.

Figure 1 relates to a sectional view of a conventional reluctance motor, particularly a switched reluctance motor 1 as a drive motor in electrically driven motor vehicles, washing machines, lawnmowers and in similar machines to be driven electrically, the stator yoke 3 consisting of sheet metal laminations, is of annular form. This stator yoke 3 has for example six salient stator poles 5/6, 7/8, 9/10, each two of which are arranged diametrically opposite each other. A rotor consisting of sheet metal laminations with salient laminated rotor poles 13, 14, 15, 16 is mounted rotatably in the stator yoke 3, in the known manner,

Moreover, coils or exciter windings 17, 18, 19, 20, 21, 22 generating a magnetic field are wound onto the stator poles 5, 6, 7, 8, 9, 10, each two windings 17/18, 19/20, 21/22 located opposite each other being connected in each case to a direct voltage source 23. Here, the individual pairs of windings 17/18, 19/20, 21/22, to generate variable magnetic fields permeating the rotor 11, are switched on and off sequentially via a control circuit in synchronisation with the rotor positions.

Figure 2 shows a circuit arrangement of an inverter 25 with the three phase branches for the SR motor 1. Each inverter branch corresponds to a separate motor phase and comprises two semiconductor switches 27/29, 31/33 and 35/37 and two freewheeling diodes 39/41, 43/45 and 47/49. These freewheeling diodes 39/41, 43/45, 47/49 connected to the corresponding stator windings 17/18, 19/20, 21/22 allow the inductive winding currents to flow in the circuit.

The three inverter phase branches are connected in parallel and are powered by the direct current source 23, which may consist of a battery or a rectified alternating current source which injects a direct voltage at the parallel inverter phase branches. A capacitor 51 is used to absorb the reverse current after a phase is switched off.

Since the switched reluctance motor 1 is to be operated with a large rotation speed range, e.g. for vehicle drives, from 0 to 9000 rpm and for washing machine drives from 0 to 15,000 rpm, a centre tap 53, 55, 57 is provided between the pole windings 17/18, 19/20, 21/22 connected in series, tapping being achieved via an additional switching transistor 59, 61, 63 in each case. With this separation of the pole windings 18, 20, 22 from the direct voltage source 23, freewheeling diodes 65, 67, 69 are provided which are arranged between the centre taps 53, 55, 57 and the pole 71 of the direct voltage source 23, to allow the inductive winding currents in the pole windings 17, 19, 21 to flow in the circuit. Centre tapping is effected as shown in figure 3 via a control circuit arrangement 75 with e.g. a microprocessor 77, which after a specific speed or a specific torque is reached, causes switching of the switching transistors 59, 61, 63 to tap the pole windings 17, 19, 21. By

isolating e.g. half the number of the pole windings in this way, higher torque is achieved in a simple manner. It is also advantageous that lower currents flow through the motor and the inverter 25 because of this measure, so that there are lower losses and more cost-effective rating losses, and more cost-effective rating of the components becomes possible. The tapping showed in figure 2 does take place in each motor phase between, in each case, two pole windings 17/18, 19/20, 21/22 connected in series one after the other, but in connection with the invention, tapping may also be effected between pairs of pole windings connected in series. Here the pairs of stator windings of each pair of stator poles opposite each other are connected in series. The distribution of the number of turns to the pole windings connected in series may also vary.

Figure 3 shows a block diagram of the control circuit arrangement 75 with the microprocessor 77, which via driver transistors 79, 81, 83 acts upon the switching elements in the three phase branches 85, 87, 89 of the inverter 25 to drive the SR motor 1. A rotor position sensor 91 outputs control pulses concerning the instantaneous position of the rotor 11 via a timing element 93 to the microprocessor.

Claims

1. A switched reluctance motor, especially as a drive motor in electrically driven motor vehicles, washing machines, lawnmowers and in similar machines to be driven electrically, which has a magnetic circuit with one or more exciter windings on the stator poles and also a ferromagnetic rotor, a switching circuit for each phase winding, in which for each a switching transistor for connecting the ends of the phase winding to the two poles of a direct current source is contained, freewheeling semiconductor switches, which are positioned parallel to the phase winding and each to a switching transistor, and has a control circuit arrangement which controls the switching transistors according to the position of the rotor, characterised in that each phase winding (7/18, 19/20, 21/22) has a tap (53, 55, 57) located approximately in its centre, which on the one hand is connected to one pole (71) of the direct voltage source (23) via a freewheeling semiconductor switch, and on the other hand via a switching transistor (59, 61, 63) to the other pole (73) of the direct voltage source (23) and is switchable via the control circuit arrangement (75) as a function of a specified speed, the part of the winding located after the tap (53, 55, 57) being separated from the direct voltage source (23).
2. A reluctance motor according to claim 1, characterised in that for each motor phase two pole windings (17/18, 19/20, 21/22) or pairs of pole windings arranged in series one after the other are provided, between which the centre tap (53, 55, 57) is arranged.

3. A reluctance motor according to claim 2, characterised in that the pole windings (17/18, 19/20, 21/22) connected in series are arranged on diametrically opposite stator poles (5/6, 7/8, 9/10).
4. A reluctance motor according to claim 2 or 3, characterised in that the pairs of stator pole windings of each pair of opposite stator poles are connected in series.
5. A reluctance motor according to one of the preceding claims, characterised in that the control circuit arrangement (75) contains a microprocessor (77) which, after a specific speed is reached, brings about the switching of the switching transistors (59, 61, 63) for tapping the pole windings (17, 19, 21) or the pairs of pole windings.

In addition, 2 pages of drawings.

Captions to figure 3:

EMV- und Überspannungsschutz	EMC and overvoltage protection
Spannungsregler	Voltage regulator
Mikroprozessor	Microprocessor
optional Schnittstellentreiber	optional interface driver
AD Wandler	AD converter